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Met O 3 Technical Note No 7

AN ANALYSIS OF THE DURATION OF RAINFALL DURING THE 'WORKING DAY', 0700 TO 1700 GMT

by

E G E KING

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AN ANALYSIS OF THE DURATION OF RAINFALL DURING THE 'WORKING DAY', 0700 TO 1700 GMT

1. Introduction

Rainfall data for the UK are often expressed in terms of the 'rainfall day', the 24 hour period commencing 0900 GMT. For many outdoor activities however, values related to the 'working day' are more appropriate. The criteria which were adopted in this analysis of rainfall during the 'working day' relate to the construction industry, but some of the results may be relevant to other activities, work or leisure, personal or commercial.

It is primarily rain that falls in working hours that affects outside work and when work on a building site is halted by rain the loss of time depends mainly on how long rain lasts, so it was rainfall duration that was studied in particular, with the 'working day' being represented by the ten hours 0700 to 1700 GMT.

Some other UK studies of rainfall during 'working days' are worthy of note: those by Foord,[1] Stevens[2] and Holmes[3] which examine the likelihood of consecutive wet days using data for London, Southampton and Manchester Weather Centres respectively and one by Dancey[4] which describes a method for determining the frequency of various rainfall amounts in the 'working day'. None of these studies, however, examines the question of the duration of the falls during the 'working day'.

2. Rain duration and outdoor work

As a generalisation, for construction work it was considered that only rain amounting to 0.2 mm or more in an hour could hinder or halt outdoor operations. Once stopped, work will usually not be restarted as long as rain is falling, however light, so that the time lost through rain might be represented by the duration of rain of any intensity provided the hourly catch is at least 0.2 mm.

3. Recording rain duration

Rainfall statistics are heavily biased towards the amount of water collected, because measuring the duration and intensity of rain is a much more complex and expensive task. Currently only about 150 stations in the UK record rain duration, while several thousand report the amount of rain which fell in 24 hours.

For many years the tilting syphon rain recorder has been the main instrument for measuring rain duration and intensity. The smallest falls of rain cannot give a detectable record but a very light fall of 0.1 mm in an hour normally allows the duration to be measured.

Another problem is that snow can become lodged in the intake of the instrument and remain there for a long time before it is recorded, so it is not possible to determine the time and rate of snowfall. On ground above about 300 m a.m.s.l precipitation in winter quite often falls as snow instead of rain; for this and other reasons the duration of precipitation over high ground is much more speculative than over low-lying areas. Except in parts of Scotland, snowfall is an infrequent occurrence on ground below about 150 m a.m.s.l, and averages of rain duration can be accepted with confidence except for the smallest falls.

4. Analysing the data

The durations and amounts of rain in each clock hour are stored on magnetic tape for about 50 stations in the UK, and for about 20 of these the data span 20 years or more.

The analysis disregarded hours with no rain, a 'trace' of rain or 0.1 mm of rain and all hours outside the period 0700 - 1700 GMT. In the remaining hours (the daytime hours with a fall of $\geq$ 0.2 mm), the rain durations in tenths of an hour were aggregated to give monthly totals of duration from which averages were derived.

The 20 stations with 20 years of data are the only points at which long-period statistics could be obtained directly by computer. The other 30 stations duration data are stored on tape only from about 1974. However, by comparing each short-period record with an adjacent long-period station's record from 1974, a factor was found for each month, which when taken with the long-period records gave viable 20 year monthly averages for the short-period station. This gave about 50 data points, spread fairly evenly over the UK, with known or simulated long-period monthly averages.

5. Monthly mean rainfall duration

The notable feature of monthly averages of daytime rain duration (Table 1) is the low values in summer months compared to the winter months, which have roughly double the summer values. This contrasts with the situation for rainfall amount where central and eastern areas have no marked seasonal variation in rainfall totals and most south coast and western districts have a monthly maximum in autumn and a minimum in spring (Fig 1).

The variation from one year to another in monthly totals of daytime rain duration is illustrated in Fig 2 which shows the upper and lower quintile values as well as the long-period averages at Birmingham airport (the upper quintile is exceeded in one year in five, on average, while in one year in five the monthly duration total is less than the lower quintile level. Thus in any given month there is a 20% chance of a daytime rain duration more than the upper quintile, perhaps much more). The inter-quintile range is large relative to the average value, so it is not unusual for an individual month's rain duration to show a quite large departure from the long-term average for the month; in Glasgow for example the daytime duration totalled 9.4 hours in May 1975 and 43.1 hours in May 1976. Because of this wide variation (the standard deviation of a station's series of 20 monthly durations is typically 50% - 60% of their average value), the monthly averages in Table 1 may sometimes be unrepresentative and too much weight should not be given to any one value or any difference between two values shown.

Seasonal averages of daytime rain duration are shown in Fig 3 as a percentage of the annual average. In most areas more than 30% of the annual rain duration is in the three months December to February and less than 20% in June to August. In mainland districts of NW Scotland there is a marked change from winter to spring: 35-40% of the total annual duration occurs in December to February, less than 20% in March to May.

6. Number of hours affected by rain

A clock hour with a total of 0.1 mm could have a whole hour of slight drizzle

or two minutes of moderate rain. Some jobs cannot tolerate as much rain as this. On the other hand some work would not be prevented by slight rain, only by moderate or heavy rain, ie a rainfall rate of at least 0.5 mm/hr. A count was made of the number of hours per month which satisfied three different criteria, (i) hours having at least 0.1 mm, (ii) hours having at least 0.2 mm and (iii) hours with a rainfall rate reaching at least 0.5 mm/hr with a rainfall amount of at least 0.2 mm. (These values are the numbers of clock hours, and are not comparable with the duration expressed in hours: During one hour the rainfall total may have been 0.2 mm but with rain falling for only 0.1 hour (6 min); the average rainfall rate would then be (0.2/0.1) or 2.0 mm/hr).

Since all the hours counted in (ii) were also counted in (i), and so on, criterion (i) gave the most hours and criterion (iii) the fewest. At all stations the three criteria produced broadly similar profiles of variation through the year, a minimum in summer and a maximum in winter; Fig 4 shows the results for Cardiff.

7. Comparison of daytime-only with 24-hour duration

Using the lowest threshold value of 0.1 mm of rain in any one hour, the average annual durations for the 0700 - 1700 GMT day were computed for 14 stations for which there were published values of average annual duration on a 24-hour basis. Because of a daytime bias in shower activity it might be expected that the 0700 - 1700 GMT day would have a smaller average duration pro rata than the 24-hour period: however, the comparison of annual durations gave 10-hour: 24-hour ratios which average 42%, or 10/24 within the limits of accuracy of the sample. All but 3 of the 14 stations ratios were in the range 40-45%.

However, this annual result does not exclude the possibility of a detectable difference between daytime and night time in the summer months at some stations.

8. Mapping Daytime Rain Duration

For stations at which both the annual duration (0700 - 1700 GMT, ignoring

hours with < 0.2 mm) and the total annual rainfall amount were known, an index Duration/Rainfall was calculated. This index showed a regional variation such that approximate values can be interpolated in areas lacking in original data. Since annual rainfall is known in detail from over 6000 raingauges in the UK the interpolated index value can be used to derive a map of Annual Average Daytime Rain Duration (Fig 5).

Since the map relies on the index interpolation it can give only a good indication of daytime rain duration but not a precise value at any point. In particular, all the reference stations were below 300 m a.m.s.l so that the map values in mountainous areas are less reliable than elsewhere. At lower altitudes the duration of rain (excluding very light falls) in daytime is broadly 150–200 hours a year in the east and 200–250 hours a year in the west. This is about 4% to 7% of the total time between 0700 and 1700 GMT. Differences between the north and the south are much smaller.

9. Wet Days

Outdoor work does not always stop and start in step with the rain. For some processes work may have to be put off all day even though rain is actually falling less than half the time. As an indication of days when outdoor work could be seriously interrupted by rain a total duration of 2 hours or more was adopted, measured only in those hours between 0700 and 1700 GMT in which the rainfall amount was $\geqslant 0.2$ mm in the hour. For the purposes of this paper such days are called 'wet days', although this is slightly inconsistent with the traditional use of this term for days with ≥ 1.0 mm in 24 hours.

Long-period monthly averages of 'wet days', like those of daytime rain duration, commonly show a winter maximum roughly double the summer minimum (Table 2). Over a large area of the UK in summer the average is only about 2 'wet days' a month.

There is an approximately linear correlation in the UK between daytime rain duration and the annual number of 'wet days' (Fig 6) so that 'wet days' could be mapped with fair confidence (Fig 7), with a geographic pattern similar to

that of daytime rain duration. Most of the urban areas have between 30 and 50 'wet days' a year, with the broad differences being between the west and the east of the country, rather than from north to south.

10. Dry Days

It is important for some purposes to have a day with no interruptions from rain, although a very light fall could be tolerated. Days in which the total amount of rain in the period 0900 to 2100 GMT was < 0.2 mm were deemed to fit this requirement. The average number of such days in each month shows only a small seasonal variation; Belfast and Edinburgh have as many 'dry days' in spring as in summer (Table 3).

In the UK the annual total of 'dry days' was broadly correlated (inversely) with the annual total of daytime rain duration (Fig 8). This allowed a map of 'dry days' (Fig 9) to be drawn to show the main geographical features. The variation across the country is relatively less on this map, there being between 210 and 260 'dry days' (on average) in nearly all urban areas.

11. Influence of topography

The monthly averages of Daytime Rain Duration, 'Wet Days' and 'Dry Days' in Tables 1 to 3 will be a good indication for the places shown, being obtained from rain recorder stations in the same region. These values however are not applicable to ground above about 200 m (650 ft) a.m.s.l. In several cities there may be a measurable difference between the city centre and the outlying suburbs at a higher altitude; the increase could be more than the difference between one place and another in the Tables. At the higher levels some increase in duration and in the number of 'wet days', and some reduction in the number of 'dry days', must be assumed. However, the effect is difficult to quantify because of lack of data.

12. Conclusion

It has been assumed here that the effect of rain on outdoor working time

is related to rain duration, ignoring small falls, during working hours. This analysis shows rain occupying from 4% to 7% of daytime hours, and confirms some earlier estimates of the effect rain can have on productivity at construction sites. Considerable variation from monthly average values is however not unusual.

Unlike rainfall amount rain duration is least in the summer months. In many places there are only about two 'wet days' a month in summer, on average.

In terms of duration, while the west is wetter than the east, these differences are not large. The north-south differences are even smaller. However, topographical features can give rise to larger variations within a few kilometres than exist between two places as distant as Belfast and Brighton.

References

1. Foord H V — An investigation into consecutive wet working days at London Weather Centre, Met. Mag., 101, 1972, pp 362-366.
2. Stevens L P — An investigation into consecutive wet working days at Southampton, Met. Mag., 103, 1974, pp 369-372.
3. Holmes J — Consecutive wet working days at Manchester Weather Centre 1961-74 Met. Office, Manchester Weather Centre Memorandum No. 5, 1975.
4. Dancey D W G — Wet working days in the United Kingdom, Met. Mag., 110, 1981, pp 12-28.

Table 1

Average Monthly Daytime Rain Duration in hours (ignoring hours with < 0.2 mm rain)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Source
ABERDEEN	29	20	18	14	22	14	18	20	21	21	18	28	243	DYCE
GLASGOW	36	23	21	18	20	15	18	20	24	27	30	31	283	ABBOTSINCH
EDINBURGH	19	15	15	16	16	10	16	18	15	16	20	17	193	TURNHOUSE
BELFAST	31	22	23	19	19	13	18	20	21	23	26	26	261	ALDERGROVE
NEWCASTLE	20	20	15	14	16	10	15	17	17	15	19	21	199	BOULMER
HARROGATE	21	16	15	15	12	10	12	14	12	13	22	19	181	LEEMING
MANCHESTER	26	22	18	19	17	16	17	18	16	19	28	25	241	RINGWAY
BIRMINGHAM	23	18	19	17	14	11	11	13	13	15	19	22	195	ELMDON
THETFORD	20	13	16	13	9	10	11	11	12	14	20	21	170	HONINGTON
CARDIFF	28	21	19	20	16	13	15	14	16	19	24	26	231	RHOOSE
PLYMOUTH	29	22	20	18	17	12	13	14	13	18	26	26	228	MOUNT BATTEN
PORTSMOUTH	23	13	14	15	13	9	8	9	14	14	22	20	174	THORNEY ISLAND
LONDON	17	11	16	15	13	9	8	9	11	13	19	19	160	HEATHROW

For example, these averages imply that at Birmingham in March rain falls during 19/31 x 10 or 6% of the 'working day' on weekdays and weekends alike; monthly averages excluding weekends may be assumed to be 5/7 of the tabulated values.

Table 2

Average Number of 'Wet Days' (those with 2 or more hours of rain, measured only in the hours between 0700 and 1700 in which the rainfall amount was ⩾ 0.2 mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Source
ABERDEEN	6	4	2½	2½	4	2	2½	2½	3	3½	3	4½	40	DYCE
GLASGOW	7	4	4	3	4	3	3½	3½	4½	5	5	5½	52	ABBOTSINCH
EDINBURGH	3	2½	3	2½	3	1½	3	3	3	3	3½	3	34	TURNHOUSE
BELFAST	6	4½	4	3½	3½	2½	3	3½	4	4	5	4½	48	ALDERGROVE
NEWCASTLE	5	4½	3	2½	2	2	2	3	3	3½	2	3½	36	BOULMER
HARROGATE	4	3	2½	3	2	2	2	2½	2	2½	3½	4	33	LEEMING
MANCHESTER	5½	4½	4	4	3½	3	3	3½	3	3½	5½	5	48	RINGWAY
BIRMINGHAM	4½	3	3½	3	2½	2	2	2½	2	2½	3½	4	35	ELMDON
THETFORD	4	2½	2½	2½	1½	1½	2	2	2	2½	4	4	31	HONINGTON
CARDIFF	5½	4	3½	4	3	2½	2½	2	3	3½	5	5½	44	RHOOSE
PLYMOUTH	5	3½	3½	3	3	2	2	2½	2½	3½	4½	5	40	MOUNT BATTEN
PORTSMOUTH	5	2½	2½	3	2	1½	1½	1½	2½	3	4½	4½	34	THORNEY ISLAND
LONDON	3½	2½	3	2½	2½	1½	1	1½	2	2½	3½	4	30	HEATHROW

Table 3

Average Number of 'Dry Days' (those with < 0.2 mm rain in the period 0900 to 2100 GMT).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Source
ABERDEEN	17	17½	20	19½	20	20	20	19	20	19½	17	18½	228	DYCE
GLASGOW	16½	17½	20	19	18½	20½	20	19	18	17½	15½	16	218	ABBOTSINCH
EDINBURGH	18	19	21	20	19½	21	21	20½	19½	20½	18½	20½	239	TURNHOUSE
BELFAST	15½	16	18½	18	17½	19	18½	18½	16	17½	16	17	208	ALDERGROVE
NEWCASTLE	18½	18½	21	20½	21½	22	21	21	21	22	18½	20½	246	BOULMER
HARROGATE	20	19	22	20½	21½	22½	21	22	21	22	19	20½	251	LEEMING
MANCHESTER	18½	18½	21½	20	20	20½	20½	20	19	20½	18	19	236	RINGWAY
BIRMINGHAM	19	18½	21½	19½	20	22	21½	22	20½	22	19½	21	247	ELMDON
THETFORD	21	20	22	21	22½	23½	21½	22½	22	22	19½	20½	258	HONINGTON
CARDIFF	18	18½	21	20½	21	22½	23	21½	19½	19	18	18½	241	RHOOSE
PLYMOUTH	16½	17	20½	20½	21½	23	23½	21	20½	20	16½	17½	238	MOUNT BATTEN
PORTSMOUTH	18½	20	22½	21	22	24	25	24	23	22½	19	20½	262	THORNEY ISLAND
LONDON	20	20	22½	20½	22	23	23	23	22	22½	20	21	259	HEATHROW

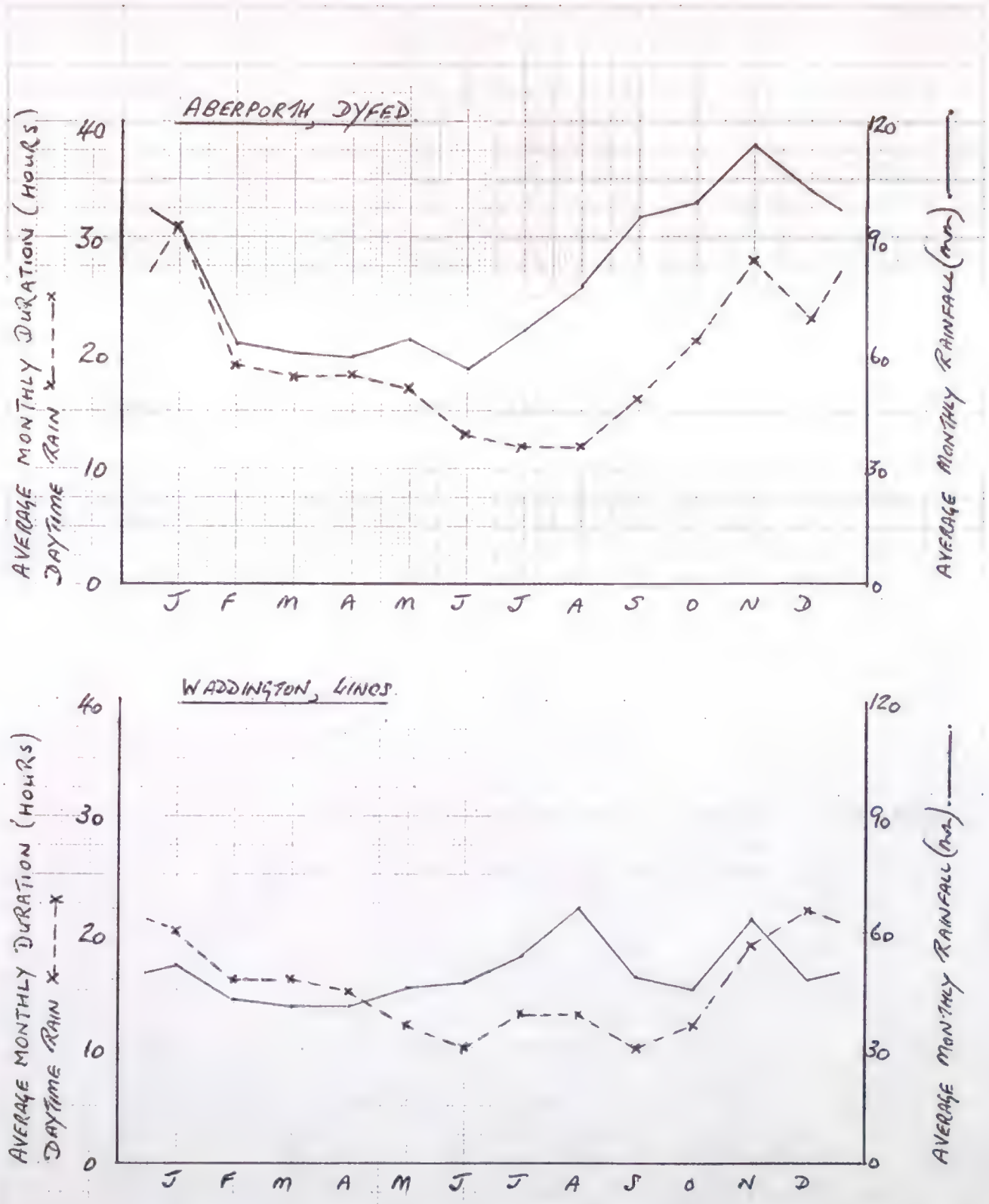

ABERPORTH, DYFED
AVERAGE MONTHLY DURATION (HOURS)
DAYTIME RAIN
AVERAGE MONTHLY RAINFALL (mm)
0
10
20
30
40
0
30
60
90
120
J F M A M J J A S O N D
WADDINGTON, LINCS
AVERAGE MONTHLY DURATION (HOURS)
DAYTIME RAIN
AVERAGE MONTHLY RAINFALL (mm)
0
10
20
30
40
0
30
60
90
120
J F M A M J J A S O N D

FIG. 1

DAYTIME RAIN DURATION

duration between 0700 & 1700 GMT
ignoring hours with amount < 0·2 mm

BIRMINGHAM (ELMDON)

AVERAGES 1959-78

WITH UPPER & LOWER QUINTILES

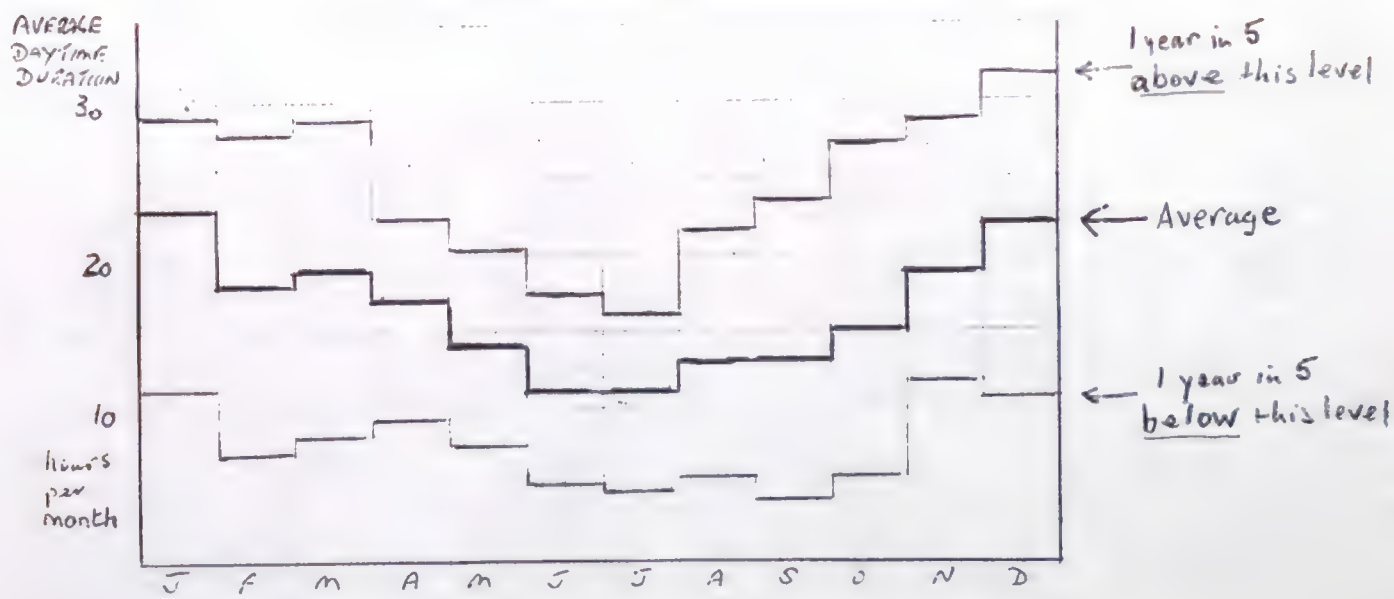
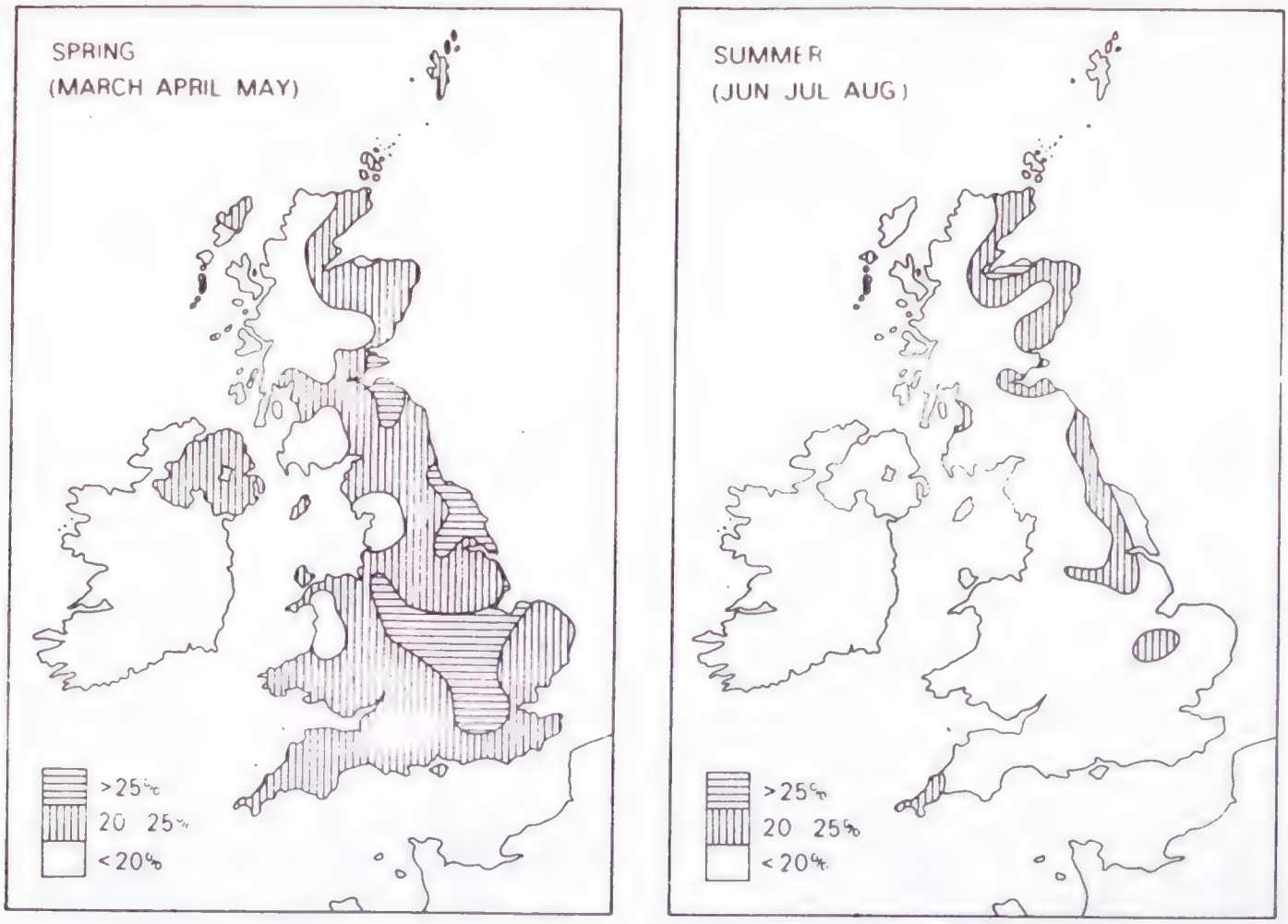


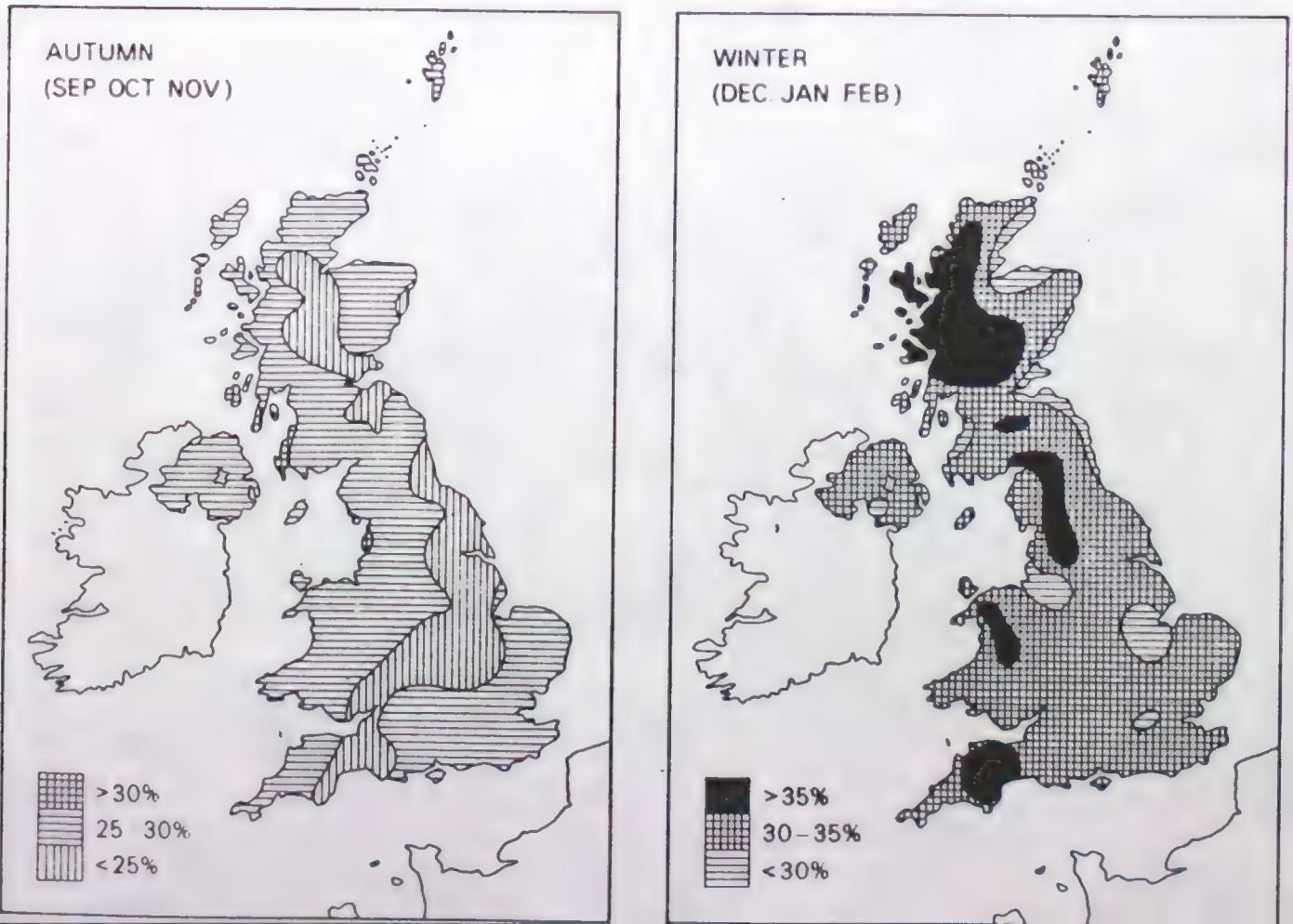
FIG. 2

FIG.3

SEASONAL AVERAGES OF DAYTIME RAINFALL DURATION EXPRESSED AS PERCENTAGES OF ANNUAL AVERAGE DAYTIME RAINFALL DURATION

From an analysis of clock hours during the period 0700–1700 GMT having ≥0.2 mm rainfall





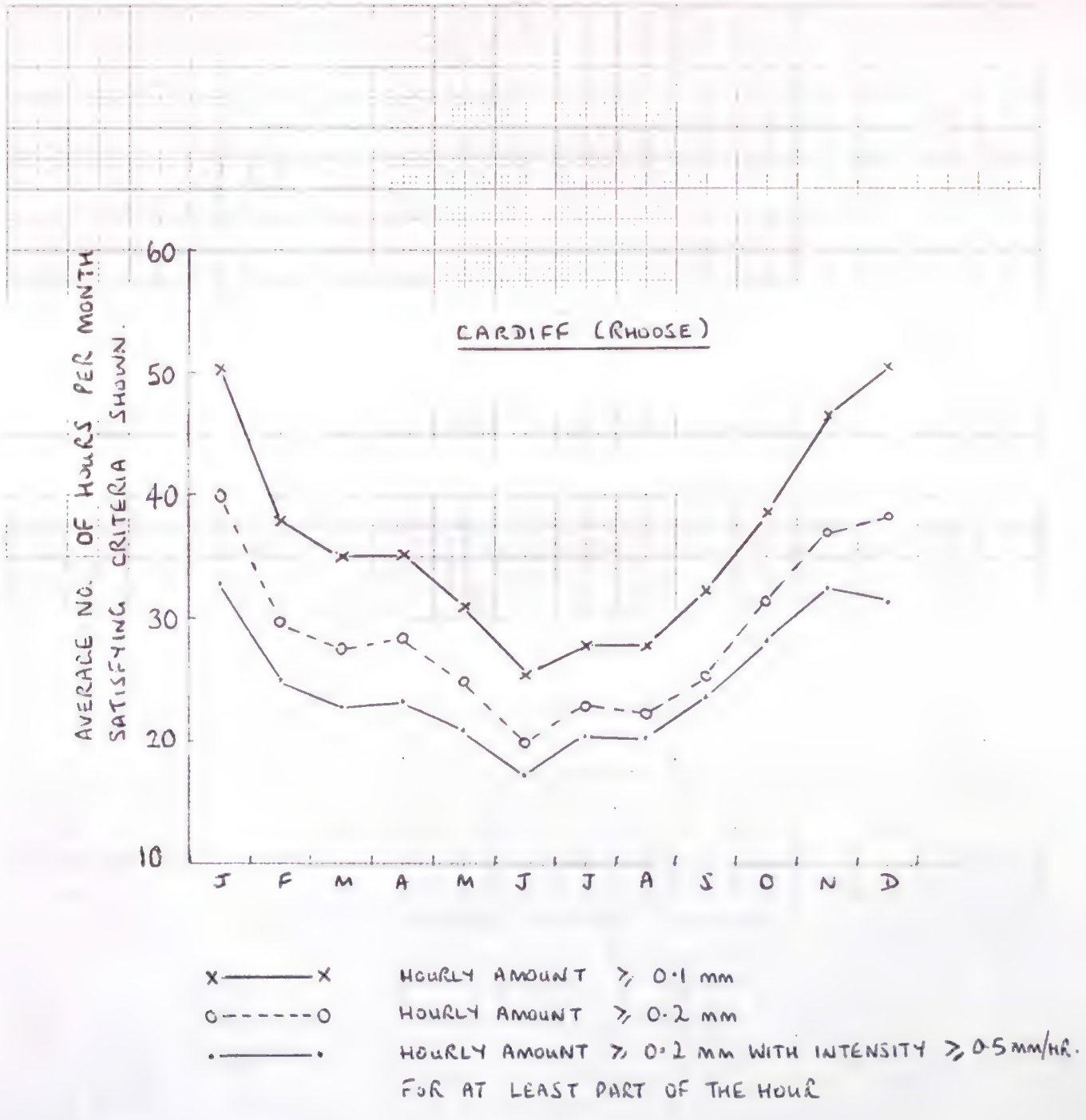
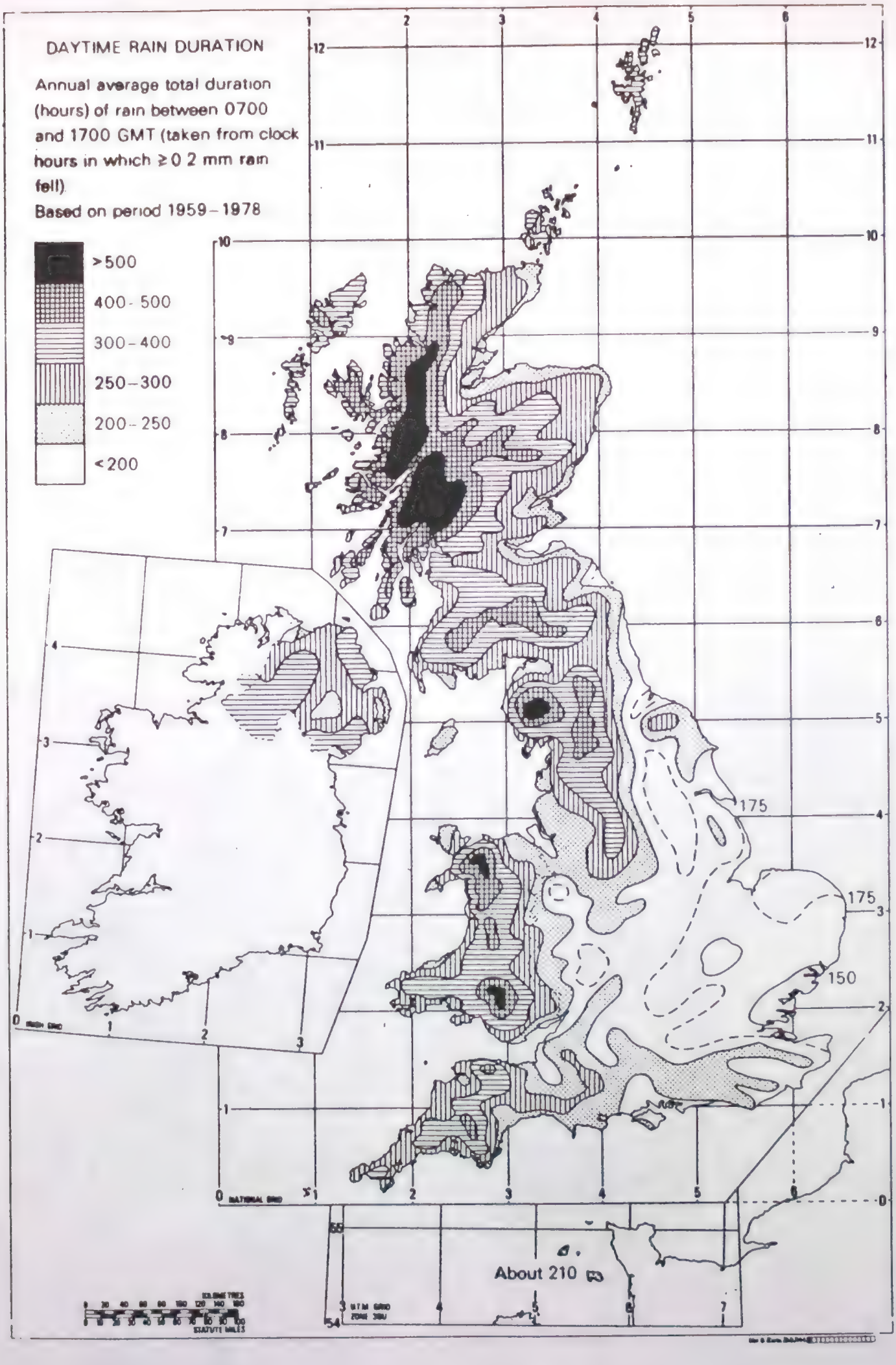

CARDIFF (RHOOSE)
AVERAGE NO. OF HOURS PER MONTH SATISFYING CRITERIA SHOWN.
60
50
40
30
20
10
J F M A M J J A S O N D
HOURLY AMOUNT ≥ 0·1 mm
HOURLY AMOUNT ≥ 0·2 mm
HOURLY AMOUNT ≥ 0·2 mm WITH INTENSITY ≥ 0·5 mm/HR. FOR AT LEAST PART OF THE HOUR

FIG. 4

FIG. 5


DAYTIME RAIN DURATION
Annual average total duration (hours) of rain between 0700 and 1700 GMT (taken from clock hours in which ≥ 0 2 mm rain fell)
Based on period 1959–1978
>500
400 - 500
300 – 400
250 – 300
200 – 250
<200
175
175
150
About 210

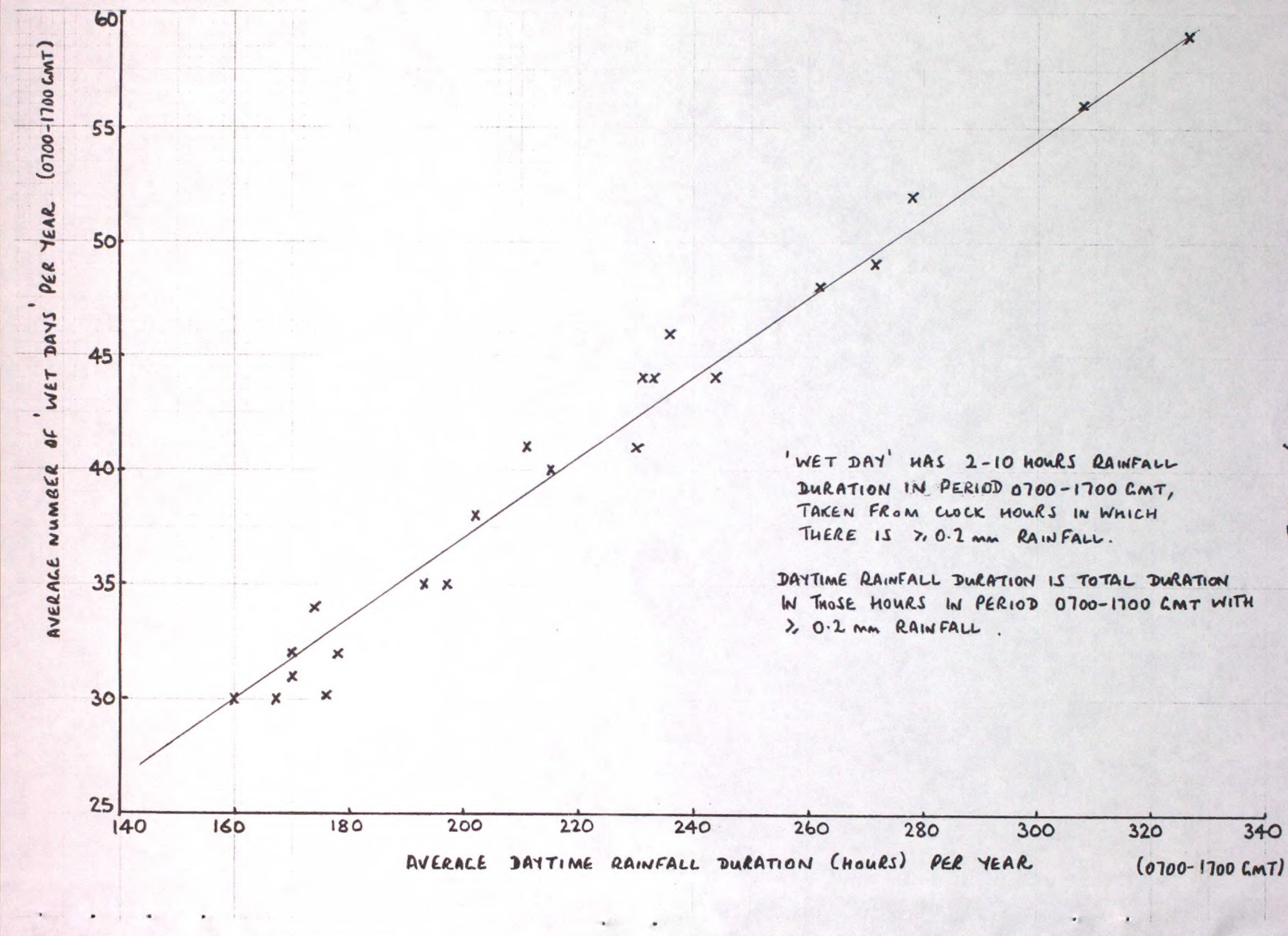
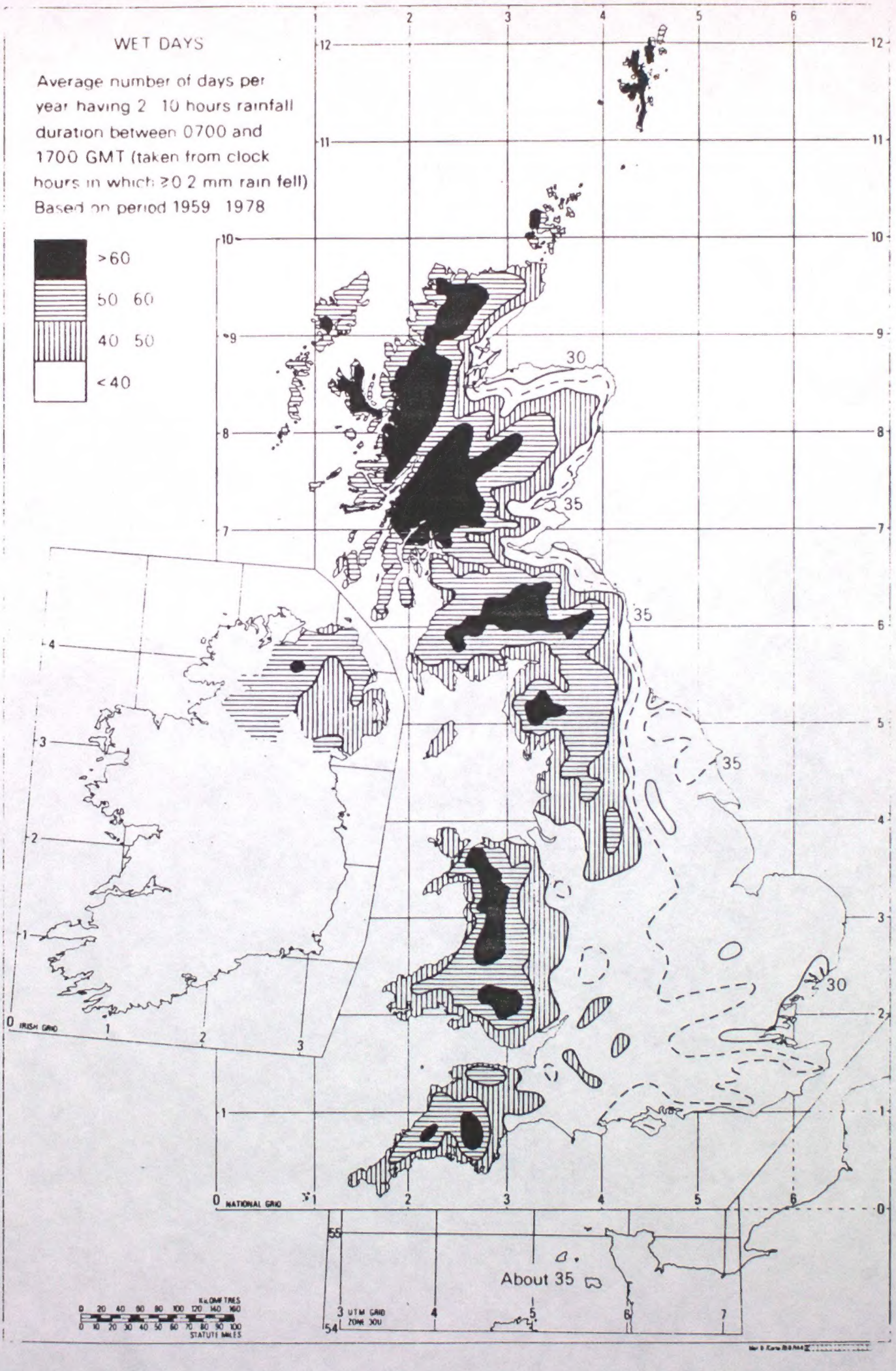

AVERAGE NUMBER OF 'WET DAYS' PER YEAR (0700-1700 GMT)
60
55
50
45
40
35
30
25
140
160
180
200
220
240
260
280
300
320
340
AVERAGE DAYTIME RAINFALL DURATION (HOURS) PER YEAR (0700-1700 GMT)
'WET DAY' HAS 2-10 HOURS RAINFALL DURATION IN PERIOD 0700-1700 GMT, TAKEN FROM CLOCK HOURS IN WHICH THERE IS ≥ 0·2 mm RAINFALL.
DAYTIME RAINFALL DURATION IS TOTAL DURATION IN THOSE HOURS IN PERIOD 0700-1700 GMT WITH ≥ 0·2 mm RAINFALL.

FIG. 6

FIG. 7


WET DAYS
Average number of days per year having 2 10 hours rainfall duration between 0700 and 1700 GMT (taken from clock hours in which ≥0 2 mm rain fell)
Based on period 1959 1978
>60
50 60
40 50
<40
30
35
35
35
30
About 35
IRISH GRID
NATIONAL GRID
UTM GRID ZONE 30U
KILOMETRES
STATUTE MILES

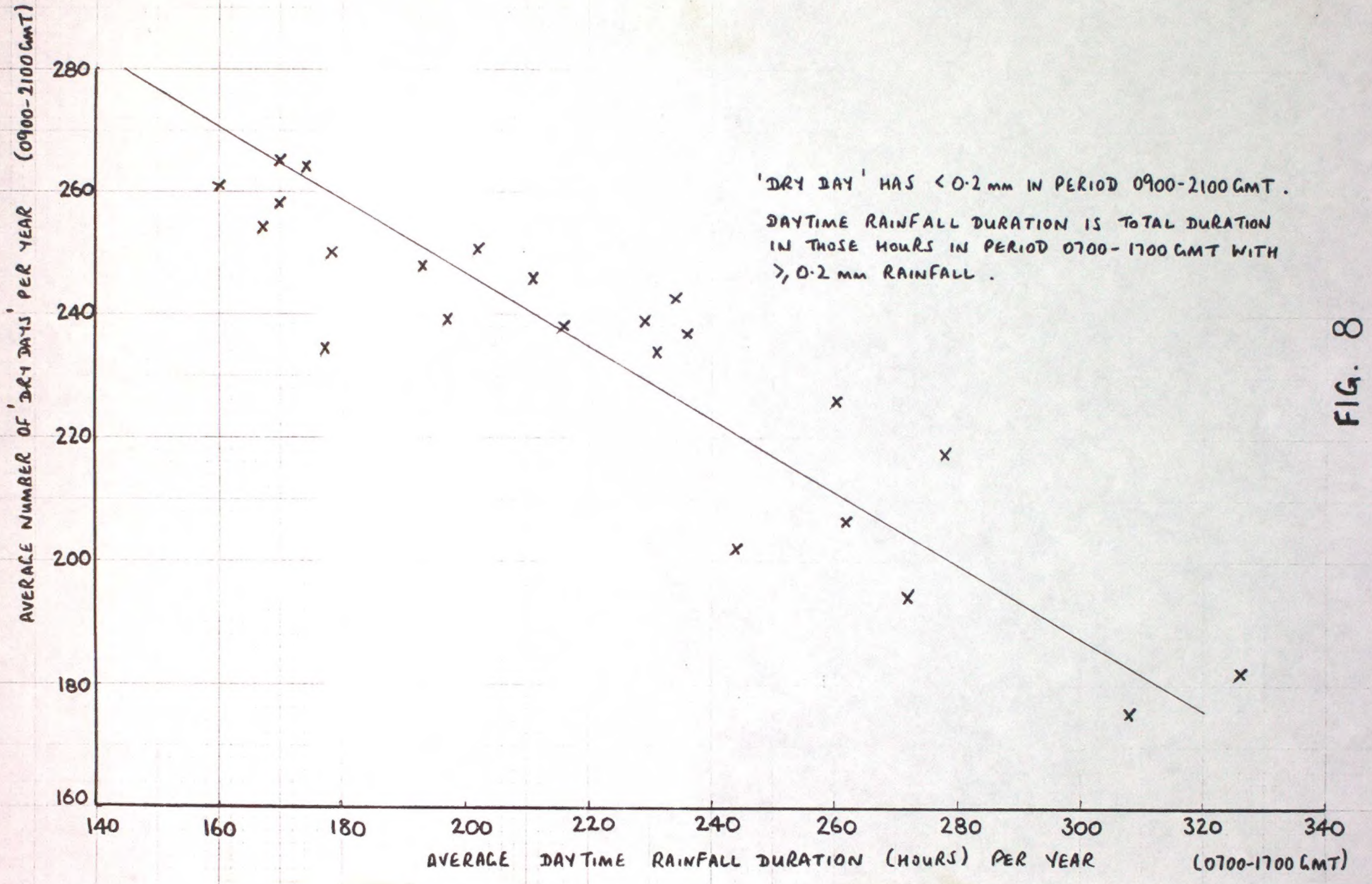
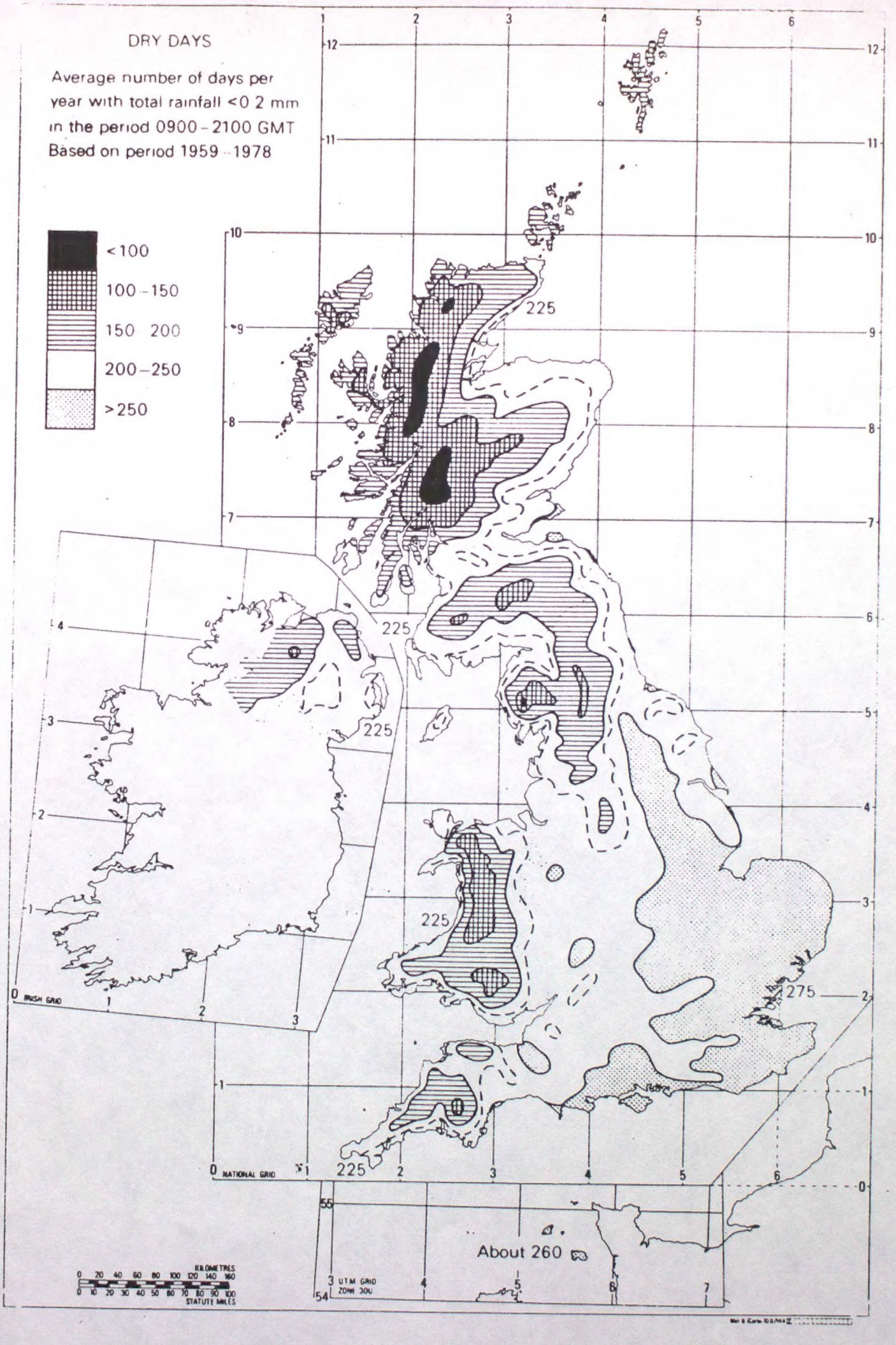

AVERAGE NUMBER OF 'DRY DAYS' PER YEAR (0900-2100 GMT)
280
260
240
220
200
180
160
140
160
180
200
220
240
260
280
300
320
340
AVERAGE DAYTIME RAINFALL DURATION (HOURS) PER YEAR (0700-1700 GMT)
'DRY DAY' HAS < 0·2 mm IN PERIOD 0900-2100 GMT.
DAYTIME RAINFALL DURATION IS TOTAL DURATION IN THOSE HOURS IN PERIOD 0700-1700 GMT WITH ≥ 0·2 mm RAINFALL.

FIG. 8

FIG. 9


DRY DAYS
Average number of days per year with total rainfall <0 2 mm in the period 0900 – 2100 GMT
Based on period 1959 – 1978
<100
100 – 150
150 200
200 – 250
>250
225
225
225
225
275
About 260
IRISH GRID
NATIONAL GRID
UTM GRID ZONE 30U
KILOMETRES
STATUTE MILES